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Nutritional value of spent mushroom substrate of *Agaricus bisporus*

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The objectives of this study were to identify the physio-chemical characteristics of *Agaricus bisporus* spent mushroom substrate (SMS). The spent mushroom substrate had desirable physical and chemical characteristics. Hydraulic conductivity of spent mushroom substrate was 6.22 m/h. The Electrical conductivity of spent mushroom substrate was 0.28 ds/m. The SMS also had desirable chemical properties like nitrogen (1.51%), phosphorus (3.77%), and potassium (0.61%). The maximum water holding capacity of SMS was 95.03%. It was concluded that spent mushroom substrate had desirable physical and chemical characteristics and suitable as a natural organic fertilizer and soil amendment for agriculture and horticulture.

Key words: *Agaricus bisporus*, nutritional, physio-chemical properties, spent mushroom substrate (SMS).

INTRODUCTION

Spent mushroom substrate (SMS) is the substrate left after harvesting mushroom fruit bodies. The mushroom production in India was 48000 tonnes in 2011-12.Consequently, one of the main problems faced by mushroom production companies is finding a way to properly dispose of the SMS without contaminating the water and soil. In fact, the lack of a sustainable waste management solution for SMS is the most significant barrier to the future development of the mushroom industry (Finney *et al.*, 2009). Spent compost is believed to be a source of humus formation and humus is to provide plants with micronutrients, for improving the soil aerations, soil water holding capacity and for contributing to the maintenance of soil structure (Kadiri and Mustapha, 2010). SMS is often regarded as an agricultural waste product with little inherent value. Mainly SMS have desirable chemical, physical, and biological properties that enhance the marketability of the substrate (Nelson and Crafts, 1996).

SMS has good physical properties. It includes the water holding capacity, soil pH, soil porosity, salt content i.e. electrical conductivity and also other important properties. Addition of SMS will add the great amount of macronutrient like nitrogen, phosphorus and potassium (NPK) and tie up nutrients but it is in little quantity (Kim *et al.* 2011). Spent mushroom compost will add marketable feature when compared to inorganic soil amendments comprised of exclusively NPK. Root zone salinity is one of the most common parameter used to manage the fertility of horticultural crops measured as the Electrical Conductivity (EC) of the sample solution, it is used as non specific indicator of nutrient status and also asses the soil salinity (Oustan*et al.*, 2007). The determination of hydraulic conductivity is essential for the assessment of fluid migration rates in the subsurface. Present investigation has been carried out to see the status of SMS for further utilization in growth promotion characteristics in agronomical as well as horticultural crops.

MATERIALS AND METHODS

Laboratory tests measured the following properties by using nutrient analysis and physiochemical properties analysis (Singh *et al.*, 2007).

Determination of available nitrogen content in sample of SMS by Alkaline Permanganate method

20 g of SMS (SMS) was transferred into 1000 ml of rounded bottom distillation flask. SMS was moistened with 20 ml of distilled water. 2 to 3 glass beads were added to prevent bumping and 1 ml of liquid paraffin to prevent frothing. 100 ml of 0.32 per cent $KMNO_4$ and 100 ml of 2.5 per cent KOH solution were added into distillation flask and immediately connected to Kjeldahls assembly. The content was distilled in Kjeldhals assembly at a steady rate and collected the liberated ammonia in the form of distillate in a 200 ml of beaker containing boric acid solution (with mixed indicator). During the absorption of ammonia pink colour of boric acid solution turned to green. 150 ml of distillate was collected. The distillate titrated with std. H_2SO_4 solution till the colour changes green to pink. Blank determination (without SMS) was carried out.

Determination of available phosphorus content in sample of SMS (Olsen's method)

0, 1, 2, 3, 4 and 5 ml of standard solution (50 ppm) was transferred into 50 ml volumetric flask to get 0, 1, 2, 3, 4 and 5 ppm, respectively. 10 ml of vandamolybdate reagent was added to each flask and make up the volume with distilled water and shaked thoroughly.Transmittance and absorbance of solution was noted after 30 min. at 470 nm. with spectrophotometer or colorimeter using blue filter. Drawn a curve by plotting absorbance/transmittance on y-axis and P concentration on x-axis.

Determination of available phosphorus content in sample of SMS

10 ml of di-acid extract was pipetted out into 50 ml of volumetric flask; 10 ml of vandamolybdate solution was added into 10 ml of distilled water, mix and made the volume up to 50 ml. The colour developed rapidly, but usually read after 30 min.A blank was prepared and noted the reading of sample on Spectroinic 20 at 470 nm wavelengths.

Determination of available potassium content in sample of SMS by neutral ammonium acetate method

Perchloric acid 173 ml was taken and 77 ml of conc. HNO_3 was taken and both the solutions were mixed in one beaker (9:4 proportions). 10 ml. of this solution was taken in each three beaker. 5 g sample of SMS was taken and transferred into in each of the beaker and thoroughly shacked for 4-5 min. After this the solution was poured on a set of digestion apparatus. for digestion for 3-4 days and after 3-4 days the solution became white transparent for nutrilization of acid and then digestion unit was closed. The solution was filtered through filter paper and impurities remained on this filter paper and extract was settled down. 5 ml solution was taken from above solution into 50 ml volumetric flask. Recording was taken in a Flame Photometer.

Determination of pH of SMS (reference electrode method)

20 g of SMS was transferred into 50 ml beaker.The solution was stirred intermittently with glass rod for 30 min.Electrode was washed with the jet of water.The electrode was inserted into the sample and the pH of sample was recorded.The electrode was removed from suspension and again washed with jet of water.

Determination of available organic carbon content in sample of SMS by Walky and Black method

0.5 to 1.0 g finely grinned sample was passed through 0.5 mm sieve and transferred into conical flask. 10 ml of 1 N potassium dichromate solution was added followed by 20 ml of conc. H_2SO_4. Content of flask were shaked for 1 min. And then 20 ml of distilled water 10 ml of orthophosphoric acid and 1 ml of diphenylamine indicator were added. The content were titrated against ferrous ammonium sulphate (std.) still colour changed from blue violet to green and simultaneously blank was run without sample of SMS.

Determination of maximum water holding capacity of SMS

Tared sample of SMS were taken in Keen Reczkowski (K.R.) boxes with the filter paper and

was recorded..K.R. boxes containing samples were kept for one night i.e. 24 h. in container, which was half filled with water. These K.R. box after fully saturated with water were removed and weight of these K.R. boxes with sample were noted. Then sample of SMS were kept in the hot air oven for 1 h and wright of the samples were noted. Triplicate reading were taken.

Determination of micronutrient content in sample of SMS by using Di-acid digestion method

Perchloric acid (173 ml) and conc. NaOH (77 ml) were taken. in a beaker. (500 ml)and thoroughly mixed 10 ml of this solution was taken in each of three beaker and . 0.5 g sample of SMS was added to it and shaked vigorously for 4-5 min. Then the solution was poured in tubes of digestion unit for digestion of sample for 3-4 days till the solution became white transparent. 50 ml of this transparent soilution was taken in a beaker and filtered through filter paper. 5 ml filtered solutions were taken in 50 ml of volumetric flask and the volume was made up to 50 ml with water and readings were taken in an Atomic absorption spectrometer.

Determination of electrical conductivity of sample of SMS

20 g of SMS was transferred into 50 ml of beaker along with 40 ml of distilled water or deionised water and stirred the suspension intermittently for 30 min. and then kept it 30 min. without touch. The conductivity cell was inserted in the clear suspension or solution and the electrical conductivity of the sample was noted.

RESULTS AND DISCUSSION

The SMS had desirable chemical and physical properties like pH, water holding capacity, organic carbon, electrical conductivity, macronutrients (NPK) and micronutrients (Zn, Mn, Cu, Fe). The experimental data are presented in Tables 1-5.

The data in Table 1 revealed that N, P and K content in sample of SMS was 1.51%, 3.77% and 0.61% respectively. This was high as compared to sample of plant extract. The nitrogen (N), phosphorus (P), and potassium (K) are the important macronutrients. These results are in agrement with Kim *et al.* (2011). The maximum water holding capacity of SMS was 95 %. These results also corroborate with the findings of Usha and Dubey (2010); and Dhillon and Sidhu (1992).

Table 1 : Determination of macronutrients contents and MWHC of the SMS.

Items	Composition of SMS (%)	Composition of plant extract (%)
Nitrogen (N)	1.51	0.91
Phosphorous (P)	3.77	1.70
Potassium (K)	0.61	0.51
Maximum water holding capacity(MWHC)(cm/hr)	95.03	-

Table 2 : Determination of pH of the SMS

Rating	pH range	SMS (pH)
Extremely alkaline	<9.0	
Strongly alkaline	8.4-9.0	
Moderately alkaline	7.6-8.3	
Slightly alkaline	7.0-7.6	7.3
Nearly neutral	7.0-6.5	
Slightly acidic	6.0-6.5	
Moderately acidic	5.3-6.0	
Strongly acidic	4.5-5.2	
Extremely acidic	>4.5	

Table 3 : Determination of organic carbon content in sample of SMS.

Rating	Organic carbon Content (%)	Organic carbon content in SMS (%)
Very low	<0.20	0.42
Low	0.21-0.40	
Moderate	0.41-0.60	
Moderately High	0.61-0.80	
High	0.81-1.00	
Very High	Greater than 1.00	

The data in Table 2 revealed that the pH of the SMS was significantly higher than that of the soil media. As per the rating shown in the table the average pH of the SMS was 7.3 which was slightly alkaline. These works correlate with the data of Fidanza and Beyer (2005).

Table 4 : Determination of micronutrients content in sample of SMS.

Micronutrients (mg/kg)	Rating					
	Low	SMS	Medium	SMS	High	SMS
Zinc(Zn)	<0.60	-	0.6-1.80	-	>1.80	2.64
Copper(Cu)	<0.20	-	0.20-0.80	0.53	>0.80	-
Iron(Fe)	<4.5	-	4.5-18.0	4.56	>18.0	-
Manganese(Mn)	<2.0	-	2.0-8.0	7.46	>1.8	-

Table 5: Determination of electrical conductivity of the sample of SMS.

Standard Electrical conductivity (EC) of soil Sample(ds/m)	Rating	Electrical conductivity of SMS
<1	Good for seed germination	
1-2	Poor seed germination	
2-3	Harmful for some crops	0.28
>3	Harmful for most crops	

Table 6: Determination of hydraulic conductivity of the SMS

Rating	Hydraulic conductivity of soil Sample	Hydraulic conductivity of SMS Sample (m/hr)
Very slow	<0.125	
Slow	0.125 -0.50	
Moderate slow	0.50 -2.0	6.22
Moderate	2.0 -6.25	
Moderately rapid	6.25 -12.5	
Rapid	12.5 -25.0	
Very rapid	>25.0	

The data in Table 3 indicated that the organic carbon content in sample of SMS was 0.42%., i.e, sample of the SMS was graded as moderate (Irun, 2007).

The data in Table 4 indicated that the micronutrient content in sample of SMS were Zn >1.80, Cu 0.53, Fe 4.56 and Mn 7.46 mg/kg of SMS. SMS media showed available nutrients levels in excess of that for an ideal substrate source and also increasing the nutrient supplying power of the growing media (Medina and Kumar. 2009). Available levels of the macronutrients were much greater in the SMS than that applied as a standard fertilizer supplement for nursery cultivation. It shows that SMS contains significantly higher available quantities of secondary nutrients (Kim *et al.* 2011).

The data in Table 5 showed that the electrical conductivity of the sample of SMS was 0.28 ds/m which was considered as good for seed germination. This work supported the view of with Findanza and Beyer (2005), who reported that the electrical conductivity or EC of the sample solution which was used as a non specific indicator of nutrient status and electrical conductivity of the saturated paste extract was 1.30 mS. cm^{-1}.

The data in Table 6 indicated that, the hydraulic conductivity of the sample of the SMS was 6.22 m/h which was considered as moderate that is good for seed germination (Delgado 2011).

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